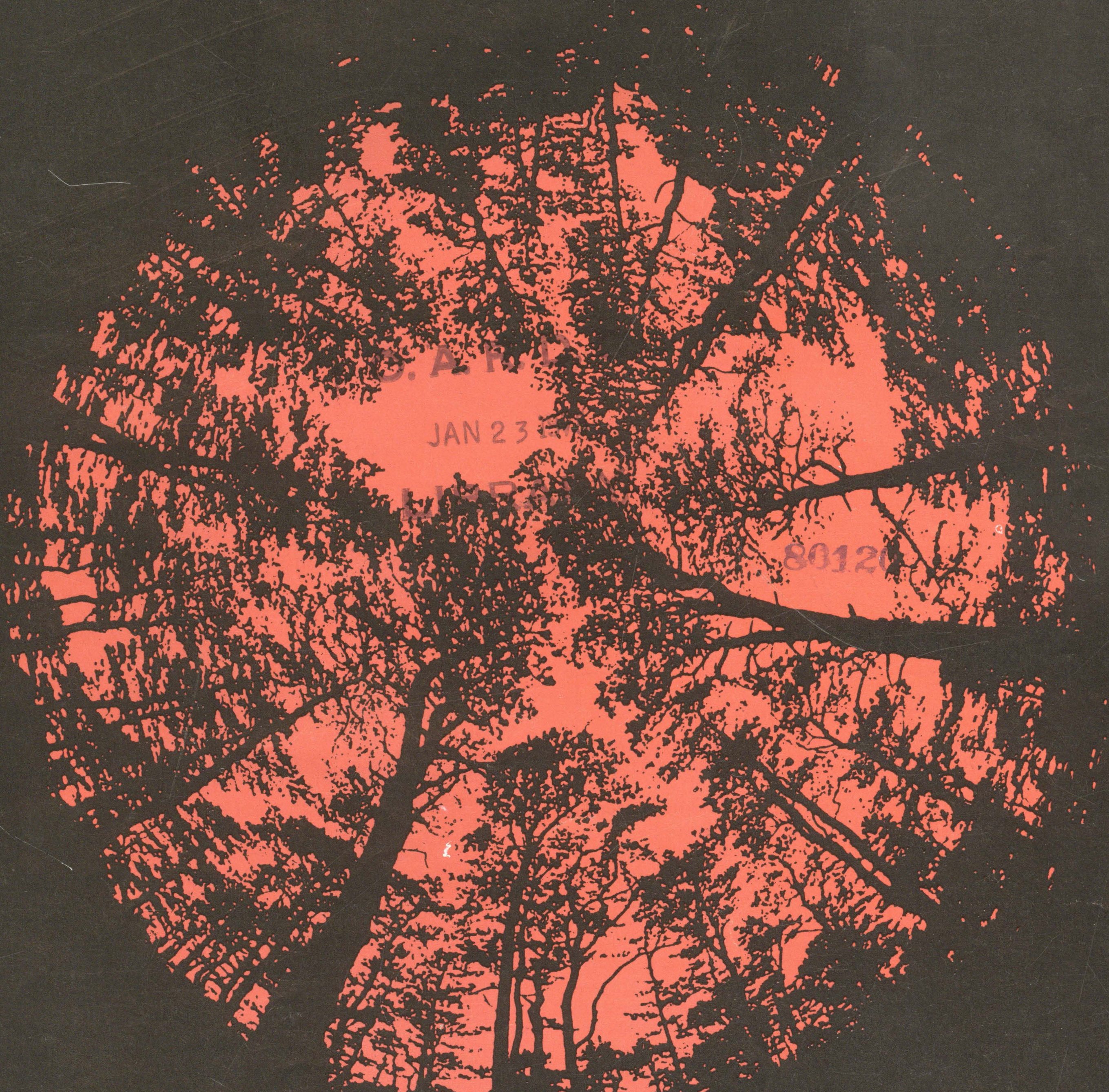
BULLETIN 629

DECAY LOSSES IN WOODLOTS



COOPERATIVE EXTENSION SERVICE
THE OHIO STATE UNIVERSITY

Reducing Decay Losses In Hardwood Forests and Farm Woodlots

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INTRODUCTION

Tree diseases cause great economic losses in commercial forests and farm woodlots. They are responsible for more wood fiber destruction each year than fire, insects, and various other natural catastrophies combined. Some diseases, like white pine blister rust, Dutch elm disease, and chestnut blight are obvious and kill or disfigure trees quite rapidly. However, most diseases, particularly the butt and trunk decays,* are insidious and can go unnoticed for years, slowly destroying the most valuable part of the tree, the butt log.

The purpose of this bulletin is to provide information primarily for the layman about ways disease organisms damage trees and how losses can be minimized. This can be done most easily by incorporating good management practices in routine care of forest and woodlot trees.

Most diseases of trees in forests and farm woodlots do not demand immediate action by the owner. However, there are a number of cultural and management practices that can be used to slow, reduce, or prevent losses, particularly those resulting from butt and trunk decay. These practices, included in a regular program of "Timber Stand Improvement" (TSI), can be applied in existing stands of most ages to insure good tree vigor and maximum wood production.

Most diseases of forest and woodlot trees are caused by fungi, mold-type organisms that grow in or on various parts of trees and cause various kinds of losses. Native disease fungi, or those that were introduced many years ago into a particular area, usually do not cause serious epidemics in native trees. This contrasts strikingly with most insect problems of forest trees. Insects usually build up to epidemic proportions quickly and tend to subside naturally. Disease problems tend to be ongoing without fluctuating shifts in severity. This is because the disease fungi and native trees have lived together for a long time and have reached an accommodating and fluctuating balance between the vigor of the tree and destructiveness of the fungi. The balance can be thrown in favor of the fungi by unusual conditions in nature such as an ice storm or other environmental influences or as a result of poor management. On the other hand, with good management practices, the balance can be turned in favor of vigorous tree growth and a reduction of disease losses.

*Foresters, loggers, scientists, and others working with trees often use specialized terms We have tried not to use specialized terms in this bulletin except where necessary. The reader may refer to the Glossary of Terms in the back of this bulletin for meanings of commonly-used technical words.

TREE MATURITY AND TIMBER STAND IMPROVEMENT

For each particular site and tree species, there is generally an average tree age beyond which it is considered overmature. As a tree is permitted to exceed its maturity age, it constitutes a greater risk of loss due to decay diseases. Therefore, it might be considered of less value than a smaller tree, since its rate of radial growth (interest on an investment) has decreased significantly. Decay disease loss in an even-aged stand of trees just maturing may be a fraction of the losses sustained when the same trees are harvested when they are overmature. Thus, a forest or woodlot must be managed with the concepts "pathological rotation" (age at which decay losses are minimal) and "economic rotation" (age at end of maximum wood production period) in mind.

Most hardwood forests and farm woodlots in Ohio are the result of natural regeneration; that is, trees originated from seeds or sprouts. Thus, to insure that the most appropriate species for a given site grows to a profitable maturity, periodic removal of undesirable trees by harvesting or killing is essential. This is called "Timber Stand Improvement" (TSI).

DISEASE AND TIMBER STAND IMPROVEMENT (TSI)

Just what management practices are used to obtain high levels of tree vigor and growth in a particular stand of trees depend in great part on numbers of trees already diseased, numbers of trees that have a good chance of becoming diseased, and the potential value of the residual trees. Potential value depends on species, total wood volume anticipated, accessibility for harvesting, and other factors.

Most TSI programs are designed to increase timber production by eliminating unproductive trees, favoring the most desirable species of trees for the site, thinning for optimum growth, selecting the best sprouts and seedlings, and doing other things to increase growth rate and tree quality. For timber production in most northeast and northcentral hardwood forests, TSI is best practiced at 5-10 year intervals. In so doing, the desired species can be kept in a vigorous growth condition and, as trees become larger, a sustained profit can be realized by thinning and selling trees for various purposes. The farm woodlot owner can also benefit from good disease control and TSI practices. He may do this routinely or whenever firewood or other timber products are needed.

In the last decade, prices paid to timber owners have increased significantly, as much as four times or more for certain selected species. The tree owner has an investment in his trees which not only should be protected but also given the best chances to increase in value. He should consider the initial cost of forested land and additional TSI costs to be the "capital investment." Increased tree growth is "interest." To get the most interest, rapid growth of the best trees is encouraged. Pest and disease damage should be reduced as much as feasible. It requires time, effort, and money to make interest and to prevent capital losses. There is little indication presently that wood product prices will come down significantly, except during occasional fluctuations, particularly for the hardwoods. So, reasonable efforts at TSI will likely be well repaid.

Fig. 1 Old, overmature trees of poor timber quality contributing little to the woodlot owner. Removal of these trees will allow young ones to grow from seeds and/or sprouts and will prevent damage to healthy smaller trees by falling branches, etc.

Fig. 4 Overmature, unproductive, and badly decayed tree. This tree should be removed to make way for more productive, healthy trees.

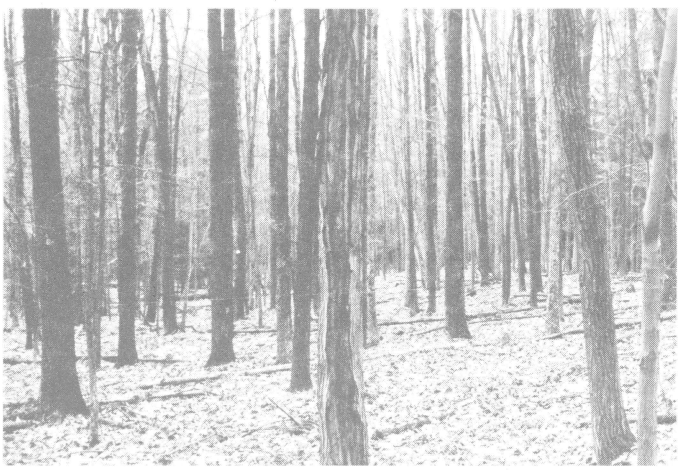

Fig. 2 An uneven-aged stand with good species diversity. If insect or disease situations arise, it is not likely that all species and sizes would be severely and equally affected.

Fig. 3 A well-spaced, uneven-aged yellow-poplar stand. Although one is represented, a selection harvest system can be operated to insure a sustained yield without a prolonged reforestation period.

TSI in Old Stands

Stands of all ages can benefit from TSI efforts. Old, occasionally even overmature, trees (Figure 1) should be managed to maintain the best level of vigor and growth possible, even though the return will not likely be so great as with young trees. One of the benefits derived from TSI in old stands is that one can determine the species, origin, and initial density of the following stand even before harvesting the old trees. This is because sprouts or seedlings of the same tree types usually replace the trees that are cut.

If large trees become weakened and die gradually, they constitute a threat to regeneration and even to larger trees in a stand. When large, dead trees break up or fall, they frequently cause large wounds on desired crop trees, increasing the risk of subsequent decay and timber loss. Dead or dying pole-sized trees remaining in a stand following a logging operation should be felled to prevent later wounding of residual trees.

Often an uneven-aged stand (Figure 3) or one containing several species (Figure 2) is desired on a particular site. If a serious insect or disease situation arises, it is not likely that all species or all age classes will be seriously affected. It is similar to not putting all the eggs in one basket. Therefore, most of the TSI work will be done on trees most subject to decay, the old trees. An advantage of working with older trees is that decay diseases are usually more evident than in young trees. Also, by removing old decayed trees in the stand (Figure 4), chances of healthy trees becoming infected are reduced.

TSI in Young Stands

A TSI program is valuable for young stands comprised of immature, rapidly-growing trees in seedling, sapling and pole stages (Figures 2, 5 and 18). There are several reasons for this, among which are:

1. Wood volume accumulation and tree growth rates are more rapid in young trees than in old trees.
2. Undesirable or potential problem trees can be eliminated at an early age without creating undesirable openings in the stand.
3. Young trees are usually less vulnerable to decay than old ones.
4. Wounds on young trees normally heal faster than on older trees. Thus, disease fungi are less likely to colonize wounds of young trees successfully than those on old trees.

TREE GROWTH

Understanding how trees grow in groups is helpful in planning disease control and TSI practices. Trees grow both in height and diameter. Height growth is relatively unaffected by the density of stocking. However, trunk diameter growth is greatly affected by stocking density. As density increases above a certain level, diameter growth rate decreases. Thus, trees that are crowded (Figure 5) may grow tall, but the trunk diameter will be smaller than that of more widely-spaced trees (Figure 3). The value of a particular tree for wood is determined primarily by its diameter. On any particular site, there is some optimum stocking density for stands of pure or mixed species.

In most tree species, two main types of wood are present — sapwood and heartwood. Because people use these terms differently, there may be some confusion in meaning. In our following discussions, we have purposely used common definitions. Interested readers may consult the publication of Shigo for a more detailed treatment of the subject.

Fig. 5 A much overcrowded stand of small saplings that, unless thinned, will not likely be very productive. Overstocking such as this causes diameter growth of individual trees to be much less than it could and should be.

Sapwood

The main stem (trunk) of a young tree and smaller stems of older trees are composed of two general zones when viewed in cross section (Figure 6). These are **bark** and **wood.** In older stems, usually those more than two or three inches in diameter, two areas can usually be distinguished in the wood. In the center of these older stems (trunk and large branches) is the **heartwood** and outer layers of wood are referred to as **sapwood.**

Separating the bark and wood is a thin layer of cells, invisible to the unaided eye, that divide and cause the tree to increase in diameter. Most of the increase occurs in the spring. Many of the new cells produced by the dividing layer toward the tree center become vertically elongated, thick-walled cells (xylem or wood). They provide support and carry water and dissolved salts from the soil to other parts of the tree.

In some tree species, considerable amounts of sugar move up from the roots in these cells, especially in the spring. Each year successive layers of these thick walled cells are formed on the inside of the dividing layer. Water and salts may move in some of these cells in older layers, but the most recently formed layer carries most of the water, salts and other nutrients. **This is the sapwood.**

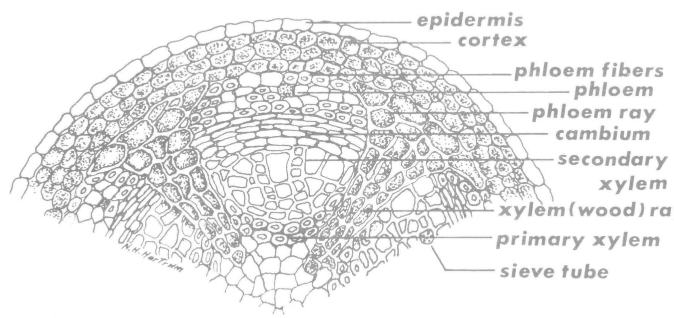

Fig. 6 Diagram of a cross section of a tree stem showing bark, cortex, cambium, phloem, and xylem (sapwood and heartwood). Drawing by N. H. Hartrum, Graphic Artist, OARDC.

Heartwood

As a healthy tree increases in diameter, certain changes take place in the inner and older layers of sapwood. Frequently, this results in a darker color. The color results from chemical changes. This portion of wood is called **heartwood** in contrast to the more recently formed sapwood, which is usually not discolored. Thus, the wood in the center of a large trunk or branch is composed of heartwood, with sapwood extending only an inch or two beneath the bark. Relatively little water and nutrients move upward in the heartwood. Heartwood usually does not begin to form until the stem or branch is more than 2-3 inches in diameter. For this reason, heartwood is not usually exposed when a branch less than this diameter is broken. As indicated above, heartwood is often darker in color (black cherry, walnut, cottonwood) than sapwood and is usually drier.

Bark

The bark of a tree is all of the cell layers to the outside of the dividing layer described earlier. Immediately to the outside of the dividing layer are the **food-conducting cells** (phloem). Sugars, amino acids and other foods manufactured in the tops of trees are transported downward in these cells. Some disease organisms invade and live primarily in this layer and kill the cells. In most young woody stems, there is a cylindrical zone of cells outside of the food-conducting cells. This is the **cortex.** As stems become older, the cortex cells are destroyed, thus eliminating this zone. Some disease-causing organisms invade the cortex of young stems and cause cankers and dieback or twig blights. The outer layer of the bark of stems more than 1-2 years old is composed of cork cells. These cells are dead and in old stems of trees, the bark may be quite thick.

BUTT AND TRUNK DECAYS — THEIR CAUSES

Nearly 80 percent of the disease losses in standing hardwood timber in the eastern and southern United States is caused by decay fungi. Consequently, owners of forest lands and woodlots should pay particular attention to preventing decay diseases. Once a tree is invaded by a decay fungus, usually there is little that can be done to eliminate the infection or cure the tree. Therefore, nearly all control efforts should be directed toward preventing decay diseases. These practices are described in the remainder of this bulletin.

Following are some general observations about decay diseases:

1. Since decay fungi enter trees primarily through wounds, **control practices are aimed primarily at minimizing the frequency and sizes of wounds.**
2. **Wounds near the soil line are particularly hazardous** (Figure 7). Decay associated with such wounds is most extensive in the butt log (Figures 8, 9, and 10); damage is likely to affect the whole tree by making it weak, unthrifty, and valueless as the decay advances.
3. **Heartwood is usually more susceptible to invasion by decay fungi than sapwood (Figure 9); thus, deep wounds into the heartwood constitute a greater disease risk than shallow wounds confined to the sapwood.**
4. **Decay disease risks usually increase as trees age.** This is because (a) the proportion of susceptible heartwood increases as trees age; (b) total numbers of wounds increase as trees age; and (c) as trees age, wounds heal over more slowly.

Decay fungi

As noted earlier, nearly all of the fungi are carried by the wind and may land in an open wound. Once spores are on the wound, and if conditions are favorable, they germinate, resulting in a thin filament that penetrates into the wood. From this filament a whole system of filaments develops, spreading in the wood up and down the trunk or branch. As these filaments of a decay fungus grow, the wood is destroyed and decay is the result.

New spores are eventually produced in "spore structures" as a result of the growth of the filaments within the tree. This is how fungi perpetuate themselves. Sometimes these structures are so small they are quite difficult to see. Many times, however, they are large (Figure 11). Large ones, called mushrooms or conks, may form on the living, diseased tree. When conks or mushrooms are growing from major trunks or branches of trees that otherwise look healthy, it is almost certain that interior

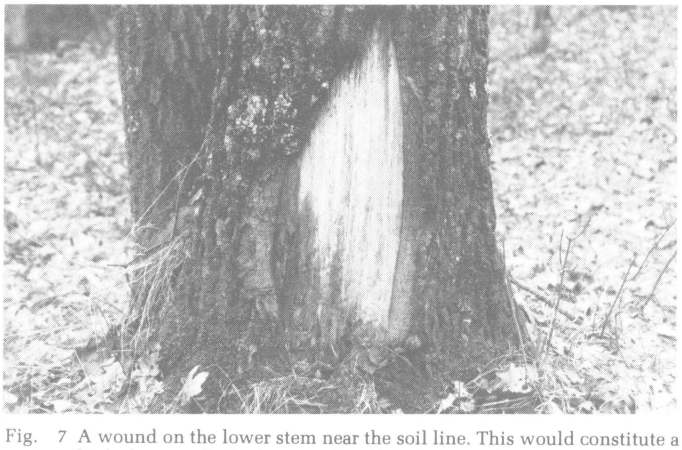

Fig. 7 A wound on the lower stem near the soil line. This would constitute a high decay risk. Such trees should be harvested as soon as possible because decay will eventually cause the most valuable portion of this tree to be worthless for lumber.

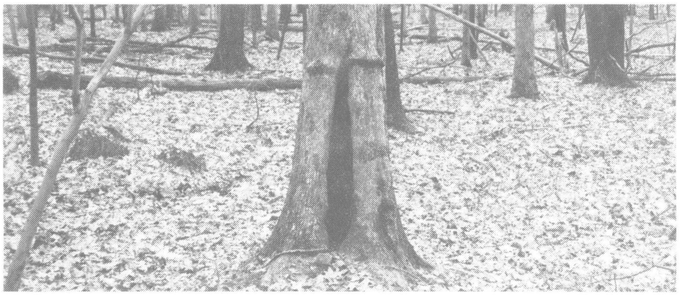

Fig. 8 Butt log decay extending a considerable distance up the stem. The entry of decay organisms probably occurred at a wound caused by fire. Such trees should be harvested or killed so space can be occupied by a more healthy individual.

Fig. 9 Decay column in the butt log, the most valuable part of the tree. Decay no doubt began many years ago in a wound that should have been recognized as a decay risk. This tree should have been removed or girdled many years ago.

Fig. 10 Extensive decay in the butt log can result in breakage during storms or when disturbed physically during logging operations, etc.

parts are decayed as a result of the fungus becoming established several years earlier. Mushrooms growing under a tree (Figure 12) usually do not indicate that the tree is diseased. This is because fungi other than disease fungi also produce mushrooms, often on soil or on fallen dead branches, leaves, etc. (Figure 13).

Fungi, in addition to causing decay in living trees, cause the degradation of branches, fallen trees, leaves, and other dead organic material, liberating carbon dioxide, a gas essential for green plant growth. Forest litter is decomposed by fungi and thus does not accumulate indefinitely.

Some fungi infect living tree roots, actually causing a beneficial effect. When small rootlets are invaded, a compound organ, termed a mycorrhiza, develops. The benefits to the tree associated in this relationship include an increased absorbing area of the roots, increased availability of nitrogen, minerals, etc., increased drought resistance, stimulated metabolic prosesses in roots, and even protection against infection by harmful organisms. The greatest benefits of mycorrhizae are realized on poor sites.

Decay Is Erratic and Takes Time

Fortunately, trees have built-in disease resistance processes so that every time a tree is wounded, decay does not always follow. In fact, decay is rare, considering all the wounds that can occur during the life of a tree. Most wounds heal over and there is only sound wood beneath. Usually wood near a wound is discolored, however, and in time the discoloration may extend within the tree some distance from the wound. Current evidence suggests that within a few days after wounding, wood at the wound edge becomes discolored and chemically changed, making it more resistant to colonization by decay fungi. Non-decay microorganisms may invade and grow in this discolored wood. Some of these organisms may even prevent the entry or slow the growth of decay fungi. Thus, discoloration appears to be linked with natural processes of a tree that work toward preventing decay. Discolored wood may be unsuitable for some purposes, but wood strength usually does not appear to be seriously affected.

If decay fungi do become established, either in a fresh wound or in discolored wood some time after wounding, usually they grow slowly within the tree. Decaying trees may be weakened and especially vulnerable to storm damage. Many years may pass before there is external evidence of decay.

Decay fungi grow within the tree most readily upward and downward from the wound; vigorous trees seem to have barriers that limit decay spread deeper than the wound or into wood formed after wounding.

Fig. 12 A nonpathogenic fungus fruiting on the litter and duff of the forest floor. Fungi such as these help to decompose dead organic matter (leaves, twigs, etc.) in the forest. Such processes lead to the eventual formation of topsoil.

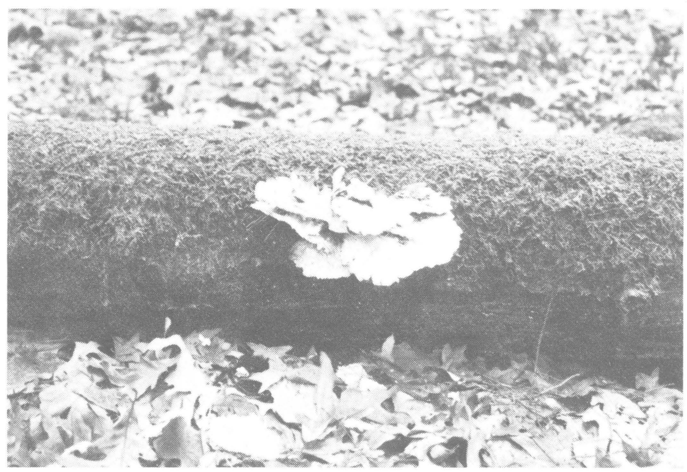

Fig. 13 A saprophytic fungus fruiting on an old, partially decayed log. These fungi help prevent a large accumulation of dead trees, limbs, etc. on the forest floor, but yet do not attack living, productive, healthy trees.

Fig. 11 Fruiting bodies (sporophores or conks) of the fungus, *Fomes rimosus*, that causes extensive decay in black locust trees. Trees having these structures on them should be harvested or killed, as they are no doubt interferring with the growth of other trees or are deteriorating faster than they are producing new wood.

PREVENTING DECAY DISEASES

For reasons explained in the previous section, it is important to reduce wounds and thus prevent the entry of decay fungi. This is often difficult, but every effort should be made to reduce wound size and frequency. A badly wounded tree is a poor risk, especially if the wound is on the butt log. The most important causes of wounds are fires, storms, insects, and logging activities.

Fire

Most fires in hardwoods are ground fires and are likely to cause damage to the butt log (Figures 7 & 15). In an unevenaged stand, damage from a fire may be apparent at first only on young trees (less than 10 years old) after about two years. Older trees may have scorched bark, but no other visible injury. Affected bark of young trees usually drops off, exposing the underlying dead wood. Damage becomes more apparent on younger than on older trees.

Fig. 14 A longitudinal crack indicative of a healed over fire injury. Such wounds are difficult to detect by casual observation, but no doubt generally conceal serious defect and/or decay. Trees such as this should be treated during TSI operations.

Fig. 15 Swollen butt of oak caused by a fire injury being subsequently invaded by decay fungi. Decay is probably extensive. This tree should be removed.

Fires do not often kill an older tree, but they may damage part of the trunk and eventually cause a "fire-scar" (Figures 7 and 14). First, dead bark loosens and falls, allowing spores of decay fungi to germinate and penetrate into the damaged sapwood. Usually the decay fungi reach the heartwood in about 4 years. Once there fungus filaments grow up the trunk causing decay, usually at a rate of about 3 inches per year. Over the years, the decayed area within the tree deepens beneath the fire wound; the butt log is ruined for lumber; and the tree grows more slowly and eventually breaks up, particularly during storms.

Typical fire scar formation on old trees begins when the bark falls from the damaged area. Gradually, the wound is healed over by bark and sapwood growth from the undamaged edges of the wound. Eventually the wound may close over, but characteristically a small area near the ground never closes completely (Figure 14). Swelling is common with the development of fire scars (Figure 15).

Reducing Fire Losses

The following suggestions may help:

1. Guard against fires where possible.
2. Remove old trees with fire scars, unless these trees are necessary for seed.
3. In young stands, old, fire-scarred trees should be girdled, if they are not removed. By killing undesirable trees at an early date in the life of the new stand, less injury to residual trees and smaller economic losses will be realized when girdled trees break up and fall.

Storms

Storms take their toll. The amount of storm damage in a stand depends on storm severity, tree species and age, site exposure, and stand density. There is no way of predicting storm severity, but one should be familiar with locations prone to storms and let this influence the species favored, stand density, and other management considerations.

Understocked stands are susceptible to windthrow and major branch breakage (Figure 16), while overstocked stands (Figure 5) are subject to top breakage due to thin, whip-like stems. Conifers are generally less susceptible to ice damage than are hardwoods, except in recently thinned stands (Figure 17). Of the northern hardwoods, black cherry is most susceptible to ice damage.

Fig. 16 Cedars in an understocked stand that have suffered heavy damage re broken major branches from snow loading. Such trees should be harvested within a couple of years at the longest.

Fig. 17 Conifers are generally more prone to top breakage from snow loading than hardwoods. Here a recently thinned stand of red pine has been severely damaged by snow.

Fig. 18 A tree stem shredded by lightning. This tree is probably dead, will become decayed, but not require special treatment unless salvaged for firewood, etc.

Fig. 19 Top damage to white birch from snow and ice. One should consider salvaging such trees if major portions of the crowns are destroyed.

Fig. 20 Severe top damage to large oak might require salvage or girdling.

Fig. 21 Bark stripping caused during logging road construction. Wounds of this size and near the ground justify harvesting such trees during normal logging operations.

Fig. 22 High-risk basal wound on oak caused during logging road construction. Salvage this tree during routine harvesting operations, since it will no doubt be too severely decayed for use by the next harvest.

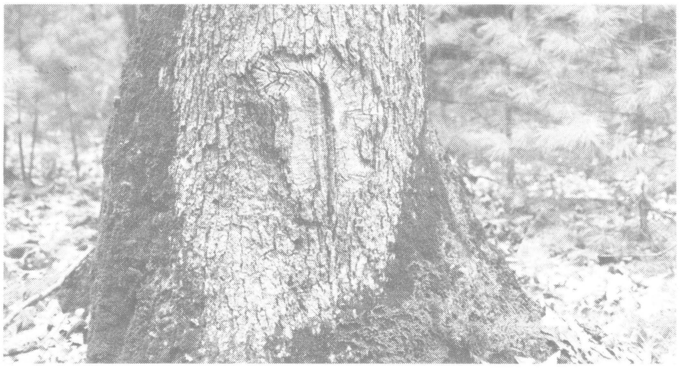

Fig. 23 Healed wound caused by log skidding. The interior portion of this white oak is probably decayed even though the healed area appears sound.

Lightning also can injure trees without killing them (Figure 18) and provide avenues for entrance of decay fungi.

Decay hazards resulting from top breakage (Figures 19 & 20) vary from species to species. Red maple and yellow-poplar over 20 years old constitute high top breakage hazards. Sugar maple and black cherry are more resistant.

Preventing Losses Due to Storms

In addition to using care in species and site selection one may:

1. Reduce the proportion of susceptible species on most storm-prone sites.
2. Remove holdovers — trees with large spreading crowns. They are easy prey for ice and wind damage. Also, when limbs fall, they can damage more valuable trees.

Should there be storm wounding, particularly wounds similar to those caused by undesirable logging operations (see next section), consideration should be given to removing wounded trees. Therefore, it may be desirable to begin routine TSI operations earlier than planned so that decay losses will be minimized in later years.

Logging Wounds

When trees are cut selectively, usually there is unavoidable wounding of some residual trees. If the wounds are serious, such trees are poor risks for future wood crops. Should logging be done on a contractual basis, there should be a firm understanding in writing that the contractor is responsible for damages.

The following are general rules for preserving residual trees:

1. Every effort should be taken to reduce top breaking, stripping of bark (Figure 21), and butt and trunk damage from heavy equipment (Figures 22 and 23).

2. Axes should not be used for marking.
3. Logging contractors should be subject to a direct penalty for unnecessarily damaging trees and damaged trees should be harvested during the logging operation.

The most serious types of damage in residual trees are:

1. Broken main stems.
2. Deep wounds extending more than 2 inches into the trunk and within 16 inches of the soil line.
3. Surface injury over 1 square foot in area on trunks or branches.
4. Broken branches over 3 inches in diameter.
5. Removal of soil causing exposure of roots.

A good time to remove residual trees that are wounded, decayed, diseased, or in other ways decay-prone is during logging operations. These types of high-risk trees are discussed in the next section on management practices.

MANAGEMENT PRACTICES REDUCE DECAY LOSSES

Stand Improvement

One of the most important justifications for routine TSI operations is to reduce the disease and decay hazard, thus insuring vigorous growth and minimizing unsuspected losses, discovered only after trees are harvested. Consequently, owners should plan periodic TSI operations with disease prevention in mind. In the following sections, guidelines are given for the early recognition of decay-prone trees.

Fig. 24 Clump of vigorous sprouts arising from a stump that has decayed. Most of these should be cut to allow growth of the favored one or two originating fairly low on the stump.

Stands of young trees of seed or sprout origin (Figure 24 and 25) should receive attention before stems are 2-3 inches in diameter. Benefits are:

1. There are many stems from which to select well-spaced potential crop trees.
2. Unwanted stems can be removed easily with a minimum of disturbance to the remaining trees.
3. Unwanted stems are small and cost less to remove.

With older trees, care must be used to remove decayed or decay-prone trees. Trees with fire, storm, or logging wounds should be removed. Also, trees with the following symptoms should be removed:

1. Exposed, decayed wood on the main trunk or major branches.
2. Open holes, blind knots (swellings indicative of callused-over branch stubs), major cankers, fungus fruiting structures, marked swellings, cracks, or areas with evidence of continuous bleeding on the trunk or major branches. These are discussed later.
3. Decayed branch stubs more than 3 inches in diameter.
4. Trees originating at high-risk positions on stumps (Figure 26).

Fig. 25 Pole-sized chestnut oak trees of sprout origin. The parent stump has decayed, leaving three sprouts. Since these stems involve a "U - type" union, two should be cut now, leaving one to grow larger.

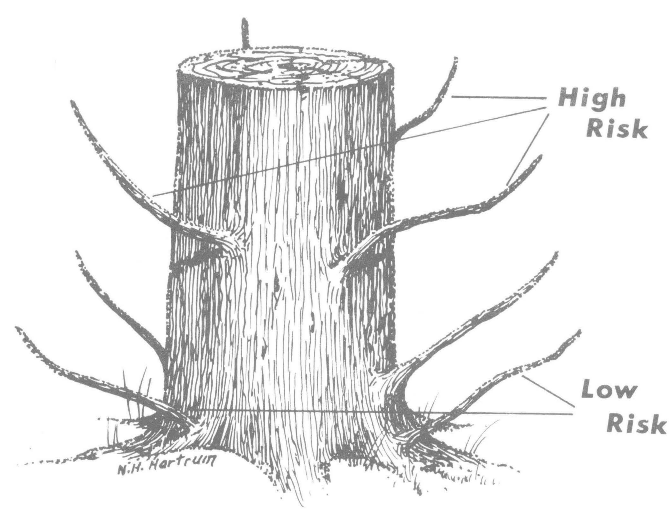

Fig. 26 A diagram of high- and low-risk sprouts re their point of origin on the parent stump. Drawing by N. H. Hartrum, Graphic Artist, OARDC.

Fig. 27, 28, 29, 30, and 31 The pictures in this plate show high-risk cankered trees that should be killed or removed from the stand. Some cankers such as those caused by *Nectria* spp. (Figures 27 and 29) seldom have decay behind them, but cause serious defects and weaken stems. Others such as Strumella cankers of oaks (Figure 31) often have decay behind them in addition to obvious surface defects.

Cankers

Cankers are diseased areas that can form on all woody parts of the tree (Figures 27-31). They are caused by fungi that are related to the decay fungi, and they also enter through wounds. Cankers are localized lesions in the bark that may be roughened, discolored, or sunken. Usually cankers are most noticeable on the trunk or major branches. Canker damage may be confined to the sapwood, or it may extend into the heartwood. Some of the canker fungi damage heartwood many feet from the actual location of the canker.

It is important that one recognize the early stages of cankering, particularly on young trees, so that during improvement work the high-risk cankered trees will not be overlooked.

General observations indicate canker development is most severe on poorer sites and is favored by understocking. In severely cankered stands, it may be necessary to convert hardwood stands to conifers or hardwood-conifer mixtures (Figure 32) to assure good timber production.

The majority of canker fungi invade trees before they are 25 years old. Older trees free of cankers will likely remain so. Cankered trees should be avoided as crop trees wherever possible. Yellow-poplar usually will rapidly heal out Nectria cankers on young trees, if trees achieve dominance as they pass into sapling stages. Trunk cankers on young walnuts, the oaks, and birches rarely heal without leaving serious tree defects. Young oaks affected by Strumella canker invariably die, break over, or become badly decayed (Figure 28 and 31).

Eutypella canker generally affects maples. Initial infection occurs when trees are young. Trees over 5 inches in diameter are seldom killed. Cankers generally occur between 2 and 8 feet above ground, and usually there is one canker per tree.

Hypoxylon cankers are found on several hardwoods, particularly aspen. Stands between 15 and 40 years old are most commonly attacked and infected trees are eventually girdled and killed. Understocking favors cankering and it is recommended that poorer aspen sites be converted to other species. In regenerating, special efforts should be made to obtain high initial stocking.

Nectria cankers are found on a wide variety of hardwoods (Figures 27 and 29). Decay rarely develops in the wood beneath these cankers. The primary damage is through the reduction in merchantable volume because of an obvious defect. However, young trees may be killed outright. Control consists of removing stem-cankered trees so residual trees will be disease-free for the final harvest.

Growth from Sprouts

In hardwood stands, trees sprouting from stumps frequently become decayed (Figure 33). The decay fungi spread from the decaying stump into the young sprout.

The high incidence of butt rot in trees of sprout origin largely offsets the advantages of using sprouts for the next crop, even though sprout growth is rapid. Commercial species which sprout readily are oaks, maples, walnut, basswood, cherry, hickory, yellow-poplar, beech, and ash.

Fig. 32 Gradual conversion of a pure hardwood stand to mixed pines and hardwoods. This is often desirable where hardwoods are on a poor hardwood site and are growing poorly or are heavily cankered.

Fig. 33 A tree with a "V-type" union from which one stem was removed. Decay is associated with the remains of the harvested stem.

Fig. 34 Sprouts of white oak fused some distance above ground, forming a "V-type" union. Cut both or leave both.

Fig. 35 Sprouts fused near the ground, forming a "U-type" union. One may be harvested without causing a significant decay risk in the other.

Fig. 36 Sprouts from a lateral root of beech (suckers). All but one healthy, straight stem should be killed.

Oak stump sprouts are very susceptible to decay spreading from the stump. Northern hardwood sprouts commonly decay through the large wound left at the base of a sprout when the parent stump rots away. Sugar and red maples, in addition to being subject to decay in stump sprouts as a result of large parent stump wounds, a high origin of sprouts, and dead stubs of companion sprouts, are subject to "blackheart," a degrading discoloration associated with wounds.

Minimizing Losses in Stands of Sprout Origin

The following practices are recommended for minimizing losses in **young sprout stands (up to 3 inches in diameter and under 20 years of age):**

1. Seedlings should be favored over stump sprouts as crop trees.
2. Remove undesirable stump sprouts as early as possible.
3. Favor single sprouts over multiple sprouts from a stump.
4. Remove sprouts with unhealed stump wounds. They are high decay risks.
5. Cut entirely or leave intact the sprouts that are fused some distance above ground (Figure 34). In the selection and thinning of fused sprouts, cut flush (with a saw) at the crotch or as nearly flush as can be done without injury to the favored sprout. Care should be taken not to loosen the bark at such cuts, as wounds will not heal over properly.
6. Favor sprouts from small stumps (less than 3-4 inches in diameter) rather than those from large stumps.
7. Sprouts originating low on the parent stump (2 inches or less from the ground) should be favored over those of higher origin.
8. Sprouts arising from old stumps usually show great resistance to decay from the parent stump (except in scarlet oak).

The following practices are recommended for reducing decay losses in **old sprout stands (over 3 inches in diameter and over 20 years of age):**

1. Cut low, smooth, slanting stumps.
2. Single sprouts are preferred to fused sprouts.
3. Sprouts with stump wounds not yet healed over or with swollen butts should be removed.
4. Clumps of large sprouts that are fused for some distance above ground level or that have low "V-type" unions should be cut entirely or left entirely intact (Figure 34). These should be avoided as crop trees, but it may be advisable to leave such sprouts as trainers.
5. It is usually advisable to leave only one stem where "U-type" unions are near the ground (Figures 25 and 35). One may be cut and one left.
6. Highest sprouts tend to outgrow lower ones. However, favor sprouts low on a stump. Fire usually prevents development of sprouts arising high on stumps, leaving only those desired from near the ground line. In clearcut areas, where practical, a fire can be used to prevent sprouts from arising at higher stump levels.
7. To encourage stump sprout growth, cut trees during the winter. Sprouts from trees cut in late spring often are weakened or killed by an early frost.

Root sprouts (suckers) may arise from unwounded roots, but usually form more abundantly if roots are wounded (Figure 36). Suckers may grow in a wide area around the parent stump, and they often provide a good distribution of young trees. Root sprouts are less subject to decay damage than stump sprouts. However, trees produced from root sprouts may be more subject to windthrow than trees of seedling or stump sprout origin.

Fig. 37, 38, and 39 Branch stubs can serve as points of entry for decay organisms. Stubs should be cut flush with the trunk to promote rapid healing and reduce the risk of decay.

Branch stubs

Dead branches and branch stubs, especially those large enough to support heartwood (more than 2-3 inches in diameter) are major entry points for decay fungi into the main trunk (Figures 37-39). If branches are broken leaving a stub, the stub should be cut flush with the trunk to promote rapid healing and reduce the possibility of decay. This can pay, particularly in high value hardwoods. Good management practices in choosing sites and appropriate species and stocking densities will result in less branch breakage.

Cracks

Vertically oriented cracks are caused by wind, lightning, frost, internal decay and severe drought (Figure 41). These cracks are usually deep and can provide infection courts for decay fungi. Wounding of this kind can be reduced by maintaining adequately stocked stands. Infolding seams (Figure 40) usually indicate nearly 100 percent cull.

Grazing

Grazing affects trees through soil compaction and root and butt damage. Root wounds caused by trampling are readily infected by fungi. It is suggested that grazing not be permitted in areas where one wishes to improve timber quality and growth rate.

Boring Insects

Some insects infest trees just beneath the bark and others infest the wood proper. Many boring insects infest trees previously weakened by drought, air pollutants, temperature extremes, and various infectious diseases. However, certain insects can successfully invade healthy trees, creating wounds through which decay and canker organisms can gain entrance into the trees. Such infested trees should be removed in stand improvement work, since they are already damaged and constitute a high risk for further deterioration. Maintaining a closed, mixed stand is one way of preventing an insect population buildup.

Fig. 40 An inrolled seam indicates much decay beneath. Such trees are unproductive and should be killed or removed to allow space for more desirable ones.

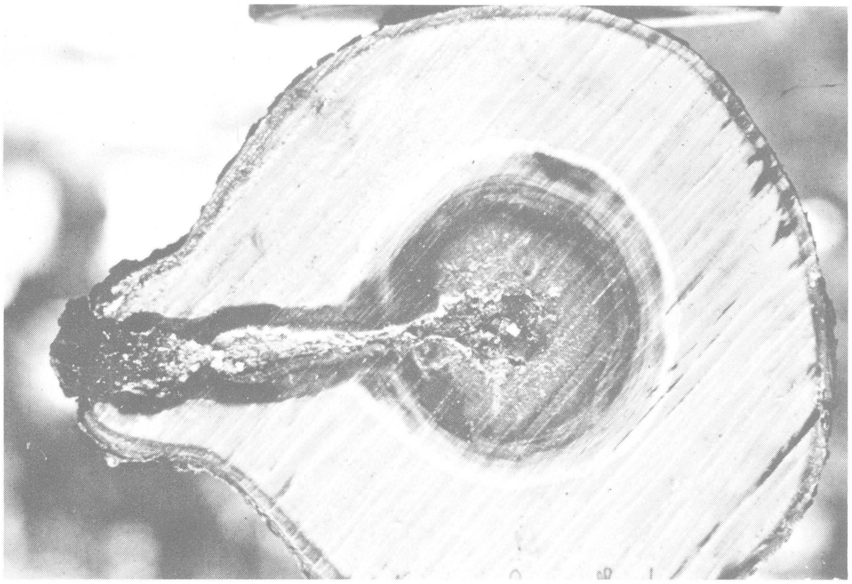

Fig. 41 Internal decay is associated with vertically oriented cracks, improperly treated branch stubs, and infolding seams.

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GLOSSARY OF TERMS

Butt — basal portion of a tree stem.

Canker — a lesion in the bark of woody plants found on twigs and stems (death of areas of the cortex or bark).

Clearcut — removal of all tree stems from a given area.

Cull loss — the loss in merchantable wood due to decay, discoloration, physical deformities or other factors causing defects.

DBH — diameter at breast height (4½ ft. above ground) outside bark.

Decay — the breakdown of wood and the change in its physical and chemical properties.

Dominance — refers to superiority in height growth, i.e., tallest trees in stand are dominant or one branch may assume dominance in becoming a stem if the main stem is destroyed.

Even-aged stand — all the trees are of one age, arising from the germination or sprouting of one year or having been planted at one time.

Hardwood — generally a deciduous, broadleaved tree.

Heartrot — a decay of the heartwood or central portion of a tree stem or branch.

Holdovers — those trees not cut during a particular harvest. They are of a merchantable size, but not cut due to lack of quality or their value in regenerating the stand after harvest.

Regeneration — the process of re-establishment of a new forest stand. May arise from seeds or sprouts.

Release — the removal of certain trees so that others may grow more vigorously with less competition.

Residual stand — the forest stand composed of standing, living trees remaining on an area following logging or other cause of tree removal or death.

Root sprout — see suckers.

Silviculture — that branch of forestry which deals with the establishment, development, care and reproduction of stands of timber.

Site — the environment of a forest, i.e., habitat or locality.

Site quality — the productive capacity of an area of forest land, usually for a given species or a combination of species.

Softwood — generally refers to coniferous tree species, i.e., pines, spruces, etc.

Sprout — branches or stems that arise from dormant buds when trees are severely pruned or suffer excessive loss of crown through breakage, cutting, insect or disease injury.

Stand — an aggregation of trees occupying a specific area and sufficiently uniform in composition (species), age, arrangement, and condition to be distinguishable from the forest on adjoining areas.

Stem — that organ of the plant which serves as mechanical support for the leaves, flowers, and fruits and furnishes a path of conduction between these organs and the roots; i.e., the main stalk.

Stocking density — refers to the number of tree stems or square feet or total cross sectional stem area per given unit area of land.

Suckers — sprouts arising from roots.

Symptom — visible evidences of an unhealthy condition in a plant.

Trainer — a tree growing in close proximity to another tree and which therefore inhibits profuse branching and irregular stem form.

Uneven-aged stand — a stand comprised of trees representing many different age classes such as young, mature, overmature, etc.

Windthrow — a tree that is uprooted and felled by wind.